What is claimed is:

1. A method for blind source separation of multiple sources, comprising:

detecting the multiple sources using an array of sensors to obtain data representative of the multiple sources;

representing the data by two mixtures having estimates of amplitude and delay mixing parameters;

updating the estimates of amplitude and delay mixing parameters, comprising the steps of:

calculating a plurality of error measures, each of the plurality of error measures indicating a closeness of the estimates of amplitude and delay mixing parameters for a given source to a given time-frequency point in the two mixtures; and

revising the estimates of amplitude and delay mixing parameters, based on the plurality of error measures;

filtering the two mixtures to obtain estimates of the multiple sources, comprising the steps of:

selecting one of the plurality of error measures having a smallest value in relation to any other of the plurality of error measures, for each of a plurality of time-frequency points in the mixtures; and

leaving unaltered any of the plurality of time-frequency points in the mixtures for which a given one of the plurality of error measures has the smallest value, while setting to zero any other of the plurality of time-frequency points in the mixtures

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for which the given one of the plurality of error measures does not have the smallest value, for each of the plurality of error measures;

outputting the estimates of the multiple sources.

2. The method of claim 1, wherein said step of representing the data by two mixtures comprises the step of computing a first mixture $x1$ and a second mixture x2 as follows:

$$x_1(t) = \sum_{j=1}^{N} s_j(t),$$

$$x_2(t) = \sum_{j=1}^{N} a_j s_j(t - \delta_j),$$

where N is a number of the multiple sources; δ_j is an arrival delay between the array of sensors resulting from an angle of arrival; a_j is a relative attenuation factor corresponding to a ratio of attenuations of paths between the multiple sources and the array of sensors; s_j (t) is a j[th] source; j is a source index ranging from 1 to N, where N is a number of the multiple sources; and t is a time argument.

3. The method of claim 1, wherein said step of calculating the plurality of error measures comprises the step of computing

$$p(a_j,\delta_j,\omega,\tau_k)=\frac{1}{1+a_j^2}\left|X_1(\omega,\tau_k)a_j e^{-i\omega\delta_j}-X_2(\omega,\tau_k)\right|^2$$

where $p(a_j,\delta_j,\omega,\tau_k)$ is an error measure for a j^{th} source; a_j and δ_j are current estimates of amplitude and delay mixing parameters, respectively; $X_1(\omega,\tau_k)$ and $X_2(\omega,\tau_k)$ are time-frequency representations of a first mixture and a second mixture of the two mixtures, respectively; k is a current time index; τ_k is a time argument corresponding to a k^{th} time index; ω is a frequency argument; and j is a source index ranging from 1 to N, where N is a number of the multiple sources.

4. The method of claim 1, wherein said step of revising the estimates of amplitude and delay mixing parameters comprises the step of computing a magnitude and a direction of change for each of the estimates of amplitude and delay mixing parameters.

5. The method of claim 4, wherein said step of computing the direction of change for each of the estimates of amplitude mixing parameters comprises the step of computing

$$\frac{\partial J(\tau_k)}{\partial a_j}=\sum_\omega \frac{e^{-\lambda\, p(a_j,\delta_j,\omega,\tau_k)}}{\sum_l e^{-\lambda\, p(a_l,\delta_l,\omega,\tau_k)}}\frac{2}{(1+a_j^2)^2}$$

$$(((a_j^2-1)\operatorname{Re}\left\{X_1(\omega,\tau_k)\overline{X_2(\omega,\tau_k)}e^{-i\omega\delta_j}\right\}$$

$$+a_j(\left|X_1(\omega,\tau_k)\right|^2+\left|X_2(\omega,\tau_k)\right|^2))$$

where $\frac{\partial J(\tau_k)}{\partial a_j}$ represents the magnitude and the direction of change in a current estimate of amplitude mixing parameter for a j[th] source that causes a largest change in correspondence between the current estimate and the data; k is a current time index; τ_k is a time argument corresponding to a k[th] time index; a_j is the current estimate of amplitude mixing parameter for the j[th] source; δ_j is a current estimate of delay mixing parameter for the j[th] source; $X_1(\omega,\tau_k)$ and $X_2(\omega,\tau_k)$ are time-frequency representations of a first mixture and a second mixture of the two mixtures, respectively; ω is a frequency argument; j and l are source indexes ranging from 1 to N, where N is a number of the multiple sources; $p(a_j,\delta_j,\omega,\tau_k)$ is an error measure for the j[th] source; λ is a smoothness parameter; and Re is a function that returns a real part of a complex number.

6. The method of claim 4, wherein said step of computing the direction of change for each of the estimates of delay mixing parameters comprises the step of computing

$$\frac{\partial J(\tau_k)}{\partial \delta_j} = \sum_{\omega} \frac{e^{-\lambda p(a_j,\delta_j,\omega,\tau_k)}}{\sum_{l} e^{-\lambda\, p(a_l,\delta_l,\omega,\tau_k)}} \frac{-2\omega a_j}{1+a_j^2} \operatorname{Im}\left\{ X_1(\omega,\tau_k)\overline{X_2(\omega,\tau_k)}\, e^{-i\omega\delta_j} \right\}$$

where $\frac{\partial J(\tau_k)}{\partial \delta_j}$ represents the magnitude and the direction of change in a current estimate of delay mixing parameter for a j[th] source that causes a largest change in

correspondence between the current estimate and the data; k is a current time index; τ_k is a time argument corresponding to a kth time index; a_j is a current estimate of amplitude mixing parameter for the jth source; δ_j is the current estimate of delay mixing parameter for the jth source; $X_1(\omega,\tau_k)$ and $X_2(\omega,\tau_k)$ are time-frequency representations of a first mixture and a second mixture of the two mixtures, respectively; ω is a frequency argument; j and l are source indexes ranging from 1 to N, where N is a number of the multiple sources; $p(a_j,\delta_j,\omega,\tau_k)$ is an error measure for the jth source; λ is a smoothness parameter; and Im is a function that returns an imaginary part of a complex number.

7. The method of claim 4, wherein said step of revising the estimates of amplitude and delay mixing parameters comprises the step of computing

$$a_j[k] = a_j[k-1] - \beta a_j[k]\frac{\partial J(\tau_k)}{\partial a_j}$$

$$\delta_j[k] = \delta_j[k-1] - \beta \delta_j[k]\frac{\partial J(\tau_k)}{\partial \delta_j}$$

where $a_j[k]$ and $\delta_j[k]$ are the estimates of amplitude and delay mixing parameters for a jth source at a time index k, respectively; ß is a learning rate constant; $\frac{\partial J(\tau_k)}{\partial a_j}$ represents the magnitude and the direction of change in a current estimate of amplitude mixing parameter for a jth source that causes a largest change in correspondence between

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the current estimate and the data; $\dfrac{\partial J(\tau_k)}{\partial \delta_j}$ represents the magnitude and the direction of change in a current estimate of delay mixing parameter for a j$^{\text{th}}$ source that causes a largest change in correspondence between the current estimate and the data; τ_k is a current time; k is a current time index; and j is a source index ranging from 1 to N, wherein N is a number of the multiple sources.

8. The method of claim 4, wherein said step of computing the magnitude of change for each of the estimates of amplitude and delay mixing parameters comprises the step of scaling the magnitude of change by a learning rate constant and a variable learning rate.

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9. The method of claim 8, wherein said step of computing the learning rate constant comprises the step of computing

$$q_j[k] = \sum_{\omega} \frac{e^{-\lambda p(a_j, \delta_j, \omega, \tau_k)}}{\sum_{l} e^{-\lambda\, p(a_l, \delta_l, \omega, \tau_k)}} \left|X_1(\omega, \tau_k)\right| \left|X_2(\omega, \tau_k)\right|$$

where $q_j[k]$ represents an amount of mixture energy that is defined by estimates of amplitude and delay mixing parameters for a j$^{\text{th}}$ source; k is a current time index; τ_k is a time argument corresponding to a k$^{\text{th}}$ time index; a_j and δ_j are current estimates of amplitude and delay mixing parameters, respectively for the j$^{\text{th}}$ source; $X_1(\omega,\tau_k)$ and $X_2(\omega,\tau_k)$ are time-frequency representations of a first mixture and a second mixture of

the two mixtures, respectively; ω is a frequency argument; j and *l* are source indexes ranging from 1 to N, where N is a number of the multiple sources; and λ is a smoothness parameter.

10. The method of claim 8, wherein said step of computing the variable learning rate comprises the step of computing

$$\alpha_j[k] = \frac{q_j[k]}{\sum_{m=0}^{k} \gamma^{k-m} q_j[m]}$$

where $\alpha_j[k]$ represents the variable learning rate; $q_j[k]$ represents an amount of mixture energy that is defined by estimates of amplitude and delay mixing parameters for a j^{th} source; γ is a forgetting factor; m is a time index ranging from 0 to a current time index k; and j is a source index ranging from 1 to N, where N is a number of the multiple sources.

11. The method of claim 1, wherein said step of selecting one of the plurality of measures comprises the step of computing

$$\Omega_j(\omega, \tau_k) = \begin{cases} 1 & p(a_j, \delta_j, \omega, \tau_k) \le p(a_m, \delta_m, \omega, \tau_k) \quad \forall m \ne j \\ 0 & otherwise \end{cases}$$

where $\Omega_j(\omega,\tau_k)$ is a time-frequency mask; $p(a_j,\delta_j,\omega,\tau_k)$ is an error measure for a j^{th} source; j and m are source indexes ranging from 1 to N, where N is a number of the multiple sources; τ_k is a current time; k is a current time index; a_j and δ_j are current estimates of amplitude and delay mixing parameters for the j^{th} source, respectively; and ω is a frequency argument.

12. The method of claim 1, wherein said leaving and setting steps comprise the step of computing

$$S_j(\omega,\tau_k) = \Omega_j(\omega,\tau_k) X_1(\omega,\tau_k)$$

where $S_j(\omega,\tau_k)$ is an estimate of a time-frequency representation of a j^{th} source; j is a source index ranging from 1 to N, where N is a number of the multiple sources; $\Omega_j(\omega,\tau_k)$ is a time-frequency mask; $X_1(\omega,\tau_k)$ is a time-frequency representation of a first mixture of the two mixtures; ω is a frequency argument; τ_k is a current time; and k is a current time index.

13. The method of claim 1, wherein said step of selecting one of the plurality of measures comprise the step of constructing a time-frequency mask based on a maximum likelihood parameter estimation.

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14. The method of claim 13, wherein said step of constructing the time-frequency mask comprises the step of computing

$$\Omega_j(\omega,\tau_k) = \begin{cases} 1 & p(a_j,\delta_j,\omega,\tau_k) \le p(a_m,\delta_m,\omega,\tau_k) \quad \forall m \ne j \\ 0 & otherwise \end{cases}$$

where $\Omega_j(\omega,\tau_k)$ is a time-frequency mask; $p(a_j,\delta_j,\omega,\tau_k)$ is an error measure for a j[th] source; j and m are source indexes ranging from 1 to N, wherein N is a number of the multiple sources; τ_k is a current time; k is a current time index; a_j and δ_j are current estimates of amplitude and delay mixing parameters for the j[th] source, respectively; and ω is a frequency argument.

15. The method of claim 1, wherein said leaving and setting steps comprise the step of computing estimates for time-frequency representations of each of the multiple sources.

16. The method of claim 15, wherein said step of computing the estimates for time-frequency representations comprises the step of computing an estimate for a j[th] source of the multiple sources as follows:

$$S_j(\omega,\tau_k) = \Omega_j(\omega,\tau_k) X_1(\omega,\tau_k)$$

where $S_j(\omega,\tau_k)$ is an estimate of a time-frequency representation of a j^{th} source; j is a source index ranging from 1 to N, where N is a number of the multiple sources; $\Omega_j(\omega,\tau_k)$ is a time-frequency mask; $X_1(\omega,\tau_k)$ is a time-frequency representation of a first mixture of the two mixtures; ω is a frequency argument; τ_k is a current time; k is a current time index.

17. The method of claim 1, wherein said filtering step comprises the step of partitioning a time-frequency representation of one of the two mixtures to demix all of the multiple sources.

18. The method of claim 1, wherein said outputting step comprises the step of reconstructing the multiple sources using a dual window function applied to the estimates.

19. The method of claim 1, further comprising the step of computing a frequency domain representation for the two mixtures, prior to said updating step.

20. The method of claim 1, further comprising the step of computing a time domain representation for the estimates of the multiple sources, prior to said outputting step.

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21. The method of claim 1, wherein said method is implemented by a program storage device readable by machine, tangibly embodying a program of instructions executable by the machine to perform said method steps.